

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Bradley J. Howard, et al.

Application No.: Not Yet Assigned

Group Art Unit: 2815

Filed: November 26, 2001

Examiner: P. Brock

For: METHOD OF CONTROLLING
STRIATIONS AND CD LOSS IN
CONTACT OXIDE ETCH

FIRST PRELIMINARY AMENDMENT

Box Non-Fee Amendment

Commissioner for Patents
Washington, DC 20231

Dear Sir:

Prior to examination on the merits, please amend the above-identified U.S. patent application as follows:

In the Specification:

Page 1, after the title, please insert -- This application is a continuation of application Ser. No. 09/292,393, filed on April 15, 1999 (currently pending), and which is hereby incorporated by reference. --

Please rewrite paragraphs 0007, 0008, 0009, 0036 and 0038 as shown in the Replacement Paragraphs:

In the Claims:

Please cancel claims 21-91.

Please amend claims 1-3, 6, 7 and 10-14 as shown in the Replacement Claims.

Replacement Paragraphs

[0007] (Amended) During photolithography, problems arise because high resolution submicrometer images in photoresist require shallow depth of focus during exposure, but thick photoresist patterns are required because of the poor etch rate between the photoresist and the underlying semiconductor layer. Additional problems occur because of the uncontrolled bake during the plasma etch processing. During this process, the substrate is exposed to ion and electron bombardment, UV light, X-rays, and scattered radiations. As a consequence, irregular topographies, distorted images and CD loss occurs during the exposure of the photoresist layer as shown in Figs. 1-2. These figures illustrate a typical plasma etch of a silicon substrate 40 having an oxide layer 42 deposited thereon. Contact holes 12, 14, 16 are etched into wafer 10. The contact holes 12, 14, 16 have an upper surface 38 and a lower surface 36. Due, in part, to the thin DUV resist and the uncontrolled bake during the etching process, discontinuities 18, 20, 22, 24, 26, 28, 30 and 46 are formed as shown for contact hole 12. The discontinuities 18, 20, 22, 24, 26, 28, 30, 46 occur in the contact hole 12 as a result of the plasma etch attacking the side walls of the contact hole 12. It should be understood that the shape and number of the discontinuities will vary depending upon the specific etching process parameters as well as the material which is being etched. The discontinuities may form which have a first surface 32 and a second surface 34 in the wall 44 of the contact hole 12. In addition, contact holes 12, 14, 16 are formed in a frusto-conical shape instead of a cylindrical shape when formed in the oxide layer 42.

[0008] (Amended) When two discontinuities 22, 46 are formed in adjacent contact holes 12, 14 and become aligned with one another, the integrated circuit suffers a loss in critical dimension (CD loss). CD loss is a critical component of integrated circuit design, especially in the sub-quarter micron regime. Additionally, when the contact holes 12, 14, 16 are formed in a frusto-conical shape instead of the desired cylindrical shape,

surface area is sacrificed thereby requiring the contact holes 12, 14, 16 to be deeper to effectuate the same contact.

[0009] (Amended) A further problem with the prior plasma etching is that as a result of the irregular contact holes 12, 14, 16, an unwanted and uncontrolled increase in the diameter of the contact holes 12, 14, 16 may also result. This increased size also impacts the displacement of the metal atoms that fill the contact holes. Thus, in addition to the loss in critical dimension, electrical contacts may also become unreliable.

[0036] (Amended) The plasma etching gas may be any gaseous material known for etching. Examples of suitable plasma etching gases are those such as HBr, Cl, fluorocarbon containing gases and the like. It should be understood that the selection of the plasma etching gas will be determined by the substrate to be etched as well as the physical parameters of the etching process such as power, pressure, temperature and the like. Examples of some preferred gases for use with the present invention include: HBr, Cl₂, carbon tetrafluoride (CF₄), trifluoromethane (CHF₃) and the like. The low power plasma is formed at low power, such as, for example, 100 to about 250 watts (RF), preferably about 150 watts.

[0038] (Amended) Reference is now made to Fig. 8. The substrate 116 is then etched out by a directional etching process such as reactive ion etching. Etching is continued down to the level of the substrate to form a set of trenches 132, 134, 136. The plasma etching is carried out under ordinary high power etching conditions. The plasma etch may be formed at a power of from about 800 to about 1100 watts (RF), preferably at from about 950 watts. Any suitable etching gas may be used in accordance with the present invention. Preferably, the same etching gases used in the low power plasma etching step are used in the high power plasma etching. In fact, it is an advantage of the present invention that the plasma etching parameters, such as gas composition, reactor pressure and the like do not need to be modified. This allows the present invention to efficiently etch the substrate 116 without the need for additional time consuming processing steps. The substrate can be contacted with the high power etch for any time sufficient to etch the

underlying substrate. It should be understood that these times may vary from about 30 seconds to over 500 seconds, depending upon the substrate, the etching gas and the physical parameters of the plasma etch. The additional photoresist 120 is then removed from the substrate 116 to arrive at the device shown in Fig. 9.

Replacement Claims

1. (Amended) A method for etching an oxide layer of a substrate, comprising:
placing a substrate having an oxide layer formed over said substrate into a reactive chamber;
introducing into said chamber an etching gas;
generating a plasma of said etching gas at a first power level and contacting said oxide layer of said substrate with said first power level plasma for a first predetermined time;
and,
generating a plasma of said etching gas at a second power level in said chamber and contacting said oxide layer of said substrate with said second power level plasma for a second predetermined time to etch said oxide layer, wherein said first and second power levels are different.
2. (Amended) The method according to claim 1, wherein said first power level is from about 100 Watts to about 250 Watts.
3. (Amended) The method according to claim 1, wherein said first power level is about 150 Watts.
6. (Amended) The method according to claim 1, wherein said second power level is from about 800 Watts to about 1100 Watts.
7. (Amended) The method according to claim 1, wherein said second power level is about 950 Watts.

10. (Amended) The method according to claim 1, wherein said first power level and said second power level plasmas of said etching gas are selected from the group consisting of Cl_2 , HBr , CF_4 , CHF_3 , CH_2F_2 and inert gases.

11. (Amended) The method according to claim 10, wherein said first power level plasma is CF_4 , CHF_3 and an inert gas.

12. (Amended) The method according to claim 10, wherein said second power level plasma is CF_4 , CHF_3 and an inert gas.

13. (Amended) The method according to claim 10, wherein said first power level and said second power level plasmas are CF_4 , CHF_3 and Ar.

14. (Amended) The method according to claim 10, wherein said first power level and said second power level plasmas are CF_4 , CHF_3 and He.


REMARKS

The specification has been amended to include a reference to prior application Serial No. 09/292,393, filed on April 15, 2001, in accordance with 37 CFR 1.78(a)(2).

Claims 21-91 have been cancelled. Claims 1-3, 6, 7 and 10-14 have been amended. The pending application now contains claims 1-20. Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached pages are captioned "Version with markings to show changes made to specification" and "Version with markings to show changes made to claims." Allowance of the application is respectfully solicited.

Dated: November 26, 2001

Respectfully submitted,

By 
Thomas J. D'Amico
Registration No.: 28,371
DICKSTEIN SHAPIRO MORIN &
OSHINSKY LLP
2101 L Street NW
Washington, DC 20037-1526
(202) 828-2232
Attorney for Applicants

Version with Markings to Show Changes Made to Specification

Paragraphs [0007], [0008], [0009], [0036] and [0038] have been amended as follows:

Paragraph [0007] at pages 2-3:

[0007] (Amended) During photolithography, problems arise because high resolution submicrometer images in photoresist require shallow depth of focus during exposure, but thick photoresist patterns are required because of the poor etch rate between the photoresist and the underlying semiconductor layer. Additional problems occur because of the uncontrolled bake during the plasma etch processing. During this process, the substrate is exposed to ion and electron bombardment, UV light, X-rays, and scattered radiations. As a consequence, irregular topographies, distorted images and CD loss occurs during the exposure of the photoresist layer as shown in Figs. 1-2. These figures illustrate a typical plasma etch of a silicon substrate 40 having an oxide layer 42 deposited thereon. Contact holes [10, 12, 14] 12, 14, 16 are etched into wafer 10. The contact holes [10, 12, 14] 12, 14, 16 have an upper surface 38 and a lower surface 36. Due, in part, to the thin DUV resist and the uncontrolled bake during the etching process, discontinuities 18, 20, 22, 24, 26, 28, 30 and 46 are formed as shown for contact hole [10] 12. The discontinuities 18, 20, 22, 24, 26, 28, 30, 46 occur in the contact hole [10] 12 as a result of the plasma etch attacking the side walls of the contact [holes 12, 14] hole 12. It should be understood that the shape and number of the discontinuities will vary depending upon the specific etching process parameters as well as the material which is being etched. The discontinuities may form which have a first surface 32 and a second surface 34 in the wall 44 of the contact hole 12. In addition, contact holes [10, 12, 14] 12, 14, 16 are formed in a frusto-conical shape instead of a cylindrical shape when formed in the oxide layer 42.

Paragraph [0008] at page 3:

[0008] (Amended) When two discontinuities 22, 46 are formed in adjacent contact holes 12, 14 and become aligned with one another, the integrated circuit suffers a loss in critical dimension (CD loss). CD loss is a critical component of integrated circuit design, especially in the sub-quarter micron regime. Additionally, when the contact holes [10, 12, 14] 12, 14, 16 are formed in a frusto-conical shape instead of the desired cylindrical shape, surface area is sacrificed thereby requiring the contact holes [10, 12, 14] 12, 14, 16 to be deeper to effectuate the same contact.

Paragraph [0009] at page 4:

[0009] (Amended) A further problem with the prior plasma etching is that as a result of the irregular contact holes [10, 12, 14] 12, 14, 16, an unwanted and uncontrolled increase in the diameter of the contact holes [10, 12, 14] 12, 14, 16 may also result. This increased size also impacts the displacement of the metal atoms that fill the contact holes. Thus, in addition to the loss in critical dimension, electrical contacts may also become unreliable.

Paragraph [0036] at page 9:

[0036] (Amended) The plasma etching gas may be any gaseous material known for etching. Examples of suitable plasma etching gases are those such as HBr, Cl, fluorocarbon containing gases and the like. It should be understood that the selection of the plasma etching gas will be determined by the substrate to [the] be etched as well as the physical parameters of the etching process such as power, pressure, temperature and the like. Examples of some preferred gases for use with the present invention include: HBr, Cl₂, carbon tetrafluoride (CF₄) trifluoromethane (CHF₃) and the like. The low power plasma is formed at low power, such as, for example, 100 to about 250 watts (RF), preferably about 150 watts.

Paragraph [0038] at page 10:

[0038] (Amended) Reference is now made to Fig. 8. The substrate 116 is then etched out by a directional etching process such as reactive ion etching. Etching is continued down to the level of the substrate to form a set of trenches 132, 134, 136. The plasma etching is carried out under ordinary high power etching conditions. The plasma etch may be formed at a power of from about 800 to about 1100 watts (RF), preferably at from about 950 watts. Any suitable etching gas may be used in accordance with the present invention. Preferably, the same etching gases used in the low power plasma etching step are used in the high power plasma etching. In fact, it is an advantage of the present invention that the plasma etching parameters, such as gas composition, reactor pressure and the like do not need to be modified. This allows the present invention to efficiently etch the substrate 116 without the need for additional time consuming processing steps. The substrate can be contacted with the high power etch for any time sufficient to etch the underlying substrate. It should be understood that these times may vary from about 30 seconds to over 500 seconds, depending upon the substrate, the etching gas and the physical parameters of the plasma etch. The additional photoresist 120 is then removed from the substrate 116 to arrive at the device shown in Fig. 9.

Version With Markings to Show Changes Made To Claims

1. (Twice Amended) A method for etching an oxide layer of a substrate, comprising:

placing a substrate having an oxide layer formed over said substrate into a reactive chamber;

introducing into said chamber an etching gas;

generating a plasma of said etching gas at a first power level and contacting said oxide layer of said substrate with said first power level plasma for a first predetermined time; and,

generating a plasma of said etching gas at a second power level in said chamber and contacting said oxide layer of said substrate with said second power level plasma for a second predetermined time to etch said oxide layer, wherein [said second power level plasma is a high power plasma and is greater than said first power level plasma, which is a low power plasma] said first and second power levels are different.

2. (Amended) The method according to claim 1, wherein said [low] first power [plasma] level is from about 100 Watts to about 250 Watts.

3. (Amended) The method according to claim 1, wherein said [low] first power [plasma] level is about 150 Watts.

6. (Amended) The method according to claim 1, wherein said [high] second power [plasma] level is from about 800 Watts to about 1100 Watts.

7. (Amended) The method according to claim 1, wherein said [high] second power [plasma] level is about 950 Watts.

10. (Amended) The method according to claim 1, wherein said [low] first power level and said [high] second power level plasmas of said etching gas are selected from the group consisting of Cl_2 , HBr , CF_4 , CHF_3 , CH_2F_2 and inert gases.

11. (Amended) The method according to claim 10, wherein said [low] first power level plasma is CF_4 , CHF_3 and an inert gas.

12. (Amended) The method according to claim 10, wherein said [high] second power level plasma is CF_4 , CHF_3 and an inert gas.

13. (Amended) The method according to claim 10, wherein said [low] first power level and said [high] second power level plasmas are CF_4 , CHF_3 and Ar.

14. (Amended) The method according to claim 10, wherein said [low] first power level and said [high] second power level plasmas are CF_4 , CHF_3 and He.